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Steel alloy for cutting details

The present disclosure relates to a material for
cutting details with high demands on, among other things,
corrosion resistance and hardness. Details of the material
should be possible to be made by photoetching, and in order
to meet these demands, a very particular combination of
properties is required according to the discussion below.

When first studying what is required for a material to
be suitable for cutting tools, the hardness is of great
importance. A harder material resists plastic deformation
better, which is a common degradation mechanism for cutting
edges – that they simply bend and/or are deflected when
stressed. Furthermore, a harder material will resist wear
better and thereby an edge will remain sharp longer, or in
other words, have better edge durability. An additional
advantage of a harder material is that the normally seen
decreasing toughness gives an improved burr breaking in
mechanical grinding and polishing, whereby a sharper edge
may be obtained. An absolute minimum in hardness of a
material intended for edges with demands on edge durability
and possibility of mechanical sharpening is judged to be 56
HRC (hardness on the Rockwell C-scale, which corresponds to
approx. 615 HV 1 kg measured as hardness in Vickers with
the load of 1 kg).

A factor that further drastically affects the edge
durability of a material is the presence of hard particles
(carbides, nitrides, and carbonitrides which henceforth are
denominated jointly as carbonitrides) in the material. An
increasing volume fraction of carbonitrides gives a
material having better edge durability. However, there are
limitations that have to be taken into consideration – the
possibility again of making a truly sharp edge by

mechanical machining or photoetching. In mechanical
machining of edges having small edge angles (< 30°),
experience shows that carbonitrides (also applying to slags
and inclusions), of a diameter larger than 10 µm, cause
tear outs and edge damage, the initial sharpness of the
edge drastically being deteriorated. For the manufacture of
edges by etching, the demands are even greater. In
photoetching, which is suitable for the manufacture of
complex details in thin materials, parts of the material
surface are protected by a protection film. On the areas
that are unprotected, the etching medium (for instance a
mixture of HCl and $FeCl_3$), which is sprayed on the surface,
is allowed to make a chemical processing. By virtue of the
different electrochemical properties of the bulk mass and
the carbonitrides, the etching will be accelerated in the
border between bulk mass and carbonitride. This entails
that the carbonitrides risk being etched out of the
material. In order for this phenomenon not to affect the
finished product negatively, carbonitrides of a diameter
larger than 5 µm must not be present in the material. A
usual cause of large carbonitrides is alloying additives of
very strong carbide formers, such as, for instance, vana-
dium, and therefore this type of alloying elements should
preferably be avoided. Another cause of large carbonitrides
is poor process control when casting and hot working the
materials. Large (Ø > 10 µm) carbonitrides, above all
angular primary carbides formed in the casting, also limits
the possibility of polishing the material shiny.

Upon corrosion attacks on martensitic stainless chro-
mium steel, they are most often of the type pitting corro-
sion. The three most important alloying elements to control
this corrosion type are chromium, molybdenum and nitrogen.
A frequently used measurement of the resistance against

pitting corrosion is the PRE-value (Pitting Resistance Equivalent), PRE = % Cr + 3,3 • % Mo + 16 • % N. Experience shows that the PRE-value according to the expression above should be above 25 for martensitic chromium steels in order
5   to attain a sufficient corrosion resistance in an environment of chloride ions.

An additional demand on the material according to the present invention is that it, in a cost-effective and quality-assured way, should be possible to harden by a con-
10 tinuous process (strip widths up to 1000 mm and strip thicknesses down to 15 μm) including furnace for the austenitizing, quenching for the conversion to martensite and finally a furnace for tempering. In the austenitizing, the carbonitrides in the material are dissolved to a certain
15 extent and the contents of alloying elements increase in the matrix. In order for this dissolution to occur evenly (enables good dimensional tolerances) and within a short time (high productivity), it is required that the carbonitrides are small in size (∅ < 5 μm) and furthermore
20 that the size distribution is even, which is controlled by an accurately controlled production process. The production process for the material includes melting of raw materials in an electric arc furnace alternatively a high frequency furnace. The content of carbon in the material can be
25 controlled by choice of raw materials or by carbon elimination either in AOD (Argon Oxygen Decarburization), CLU (Creusot Loire Uddeholm) or another refining process. As an alternative, the material may be remelted in a secondary metallurgical process such as VIM (Vacuum
30 Induction Melting), VAR (Vacuum Arc Remelting), ESR (Electroslag Remelting), or the like. Casting may take place in the traditional way into ingot or by continuous casting. A first strong reduction is made in the warm

state, and then the material is spheroidized. Next, cold
rolling is carried out in a plurality of steps including
intermediate annealing operations. The material may be
delivered to customer either in cold-rolled, annealed, or
5   hardened and tempered form. The stainless martensitic
chromium steel according to the discussion above has
advantages to austenitic materials for the manufacture of
details by photochemical processing. These advantages are,
among other things, that the material after hardening has a
10 very good flatness and is almost strain free. The material
also allows a good productivity for this type of machining.

In order to be able to meet the demands above and
simultaneously produce a finished material in strip form in
a cost-effective way, a very accurate optimization is
15 required of above all alloying elements, but also process
parameters. For the production cost to end up on a reason-
able level, it is required that the material can be pro-
duced by a normal (non-pressurized) metallurgical process.
This gives a practical limitation in the content of nitro-
20 gen of maximum 0,20 % by weight, in a well-controlled proc-
ess. Therefore, the content of nitrogen should be between
0,15-0,20 % by weight. The hardness of the material in the
hardened form is substantially determined by the content
(carbon + nitrogen) in % by weight, and in order to be able
25 to attain a hardness of over 56 HRC without deep freezing,
with sufficient remaining volume fraction of carbonitrides
for the edge durability, this sum has to be greater than
0,55 % by weight, provided that high contents of car-
bonitride formers such as chromium and molybdenum are pres-
30 ent. This entails that the content of carbon generally has
to be above 0,40 % by weight and that the ratio of carbon
to nitrogen becomes greater than 2. With this relatively
high content of carbon, the carbon activity has to be

limited for avoiding formation of primary carbides in the solidification, which is provided by keeping the content of silicon low, i.e. within the interval of 0,1-1,0%, preferably 0,1-0,80 %, most preferably 0,15-0,55 %, by

5   weight. In the hardening, the material is austenitized at 950-1150 °C, preferably 1000-1070 °C, and then quenched (suitably in oil, between cooling clamps or by means of compressed air) to room temperature. A tempering is made at about 200 °C in order to achieve a hardness > 56 HRC. With

10 deep freezing to -80 °C before tempering, an additional hardness enhancement of about 2 HRC can be attained.

        Chromium has to be added to the material in a suffi-cient quantity in order to form a corrosion-protecting oxide film on the material surface, but at high contents of

15 chromium, again the risk of the formation of large primary carbides arises, which has to be avoided. Therefore, the content of chromium should be 12-15 %, preferably 13-15 %, most preferably 14-15 %, by weight. Molybdenum is then added in sufficient quantity to give a PRE > 25. A suitable

20 content of Mo is 2,5-4,0 %, preferably 2,6-4,0 %, most preferably 2,6-3,0 %, by weight. At high additions of molybdenum and nitrogen, it is risked that the hot working properties of the material are deteriorated, and in order to limit this risk, other elements having similar effect

25 should be kept on a minimal level – the content of copper has to, for instance, be kept below 0,1 % by weight. Nickel and cobalt are expensive alloying materials, which are stable in a normal metallurgical process, which means that the contents are accumulated over time in steel making

30 based on recycled steel. For stainless steels, there are limitations as regards the content of nickel of max 1 % in order for the material not to be classified as potential carcinogenic and allergenic according to the Euro directive

99/45/EC, and therefore this content has been set as a maximum content regarding nickel for the alloy according to the patent. Preferably, nickel is not added actively in the material and the content of nickel is determined to max.

5   0,7 % in order to avoid the austenite stabilization that otherwise would be the consequence. The alloy also contains 0,1-1,0 %, preferably 0,4-0,8 %, most preferably 0,4-0,7 %, by weight, of Mn which is another element that stabilizes the austenite. The maximum content of cobalt has been set

10   to 4 %, on one hand because of the expense and on the other hand to avoid too a fast accumulation of cobalt in the processing of recycled steel depending on the element normally being seen as an impurity in stainless steel, above all within the nuclear power industry. Preferably, cobalt

15   is not added actively in the material and the content of cobalt is set to max 0,5 %, in spite of the increasing impact of the element on the martensite formation temperature. Hence, an addition of cobalt may displace the phase transformation upon cooling after hardening toward more

20   martensite.

In consideration of today's standard materials, it is observed that it is very few that meet the demand PRE > 25 in combination with HRC > 56. Adding the demand on carbonitrides Ø < 5 μm, there are no standard materials that meet

25   them. Materials of the type AISI 440 C meet, for instance, only the demand on hardness. In order to meet the demands on PRE-value and carbonitrides according to the above, there are only austenitic and duplex materials available, but in these, the hardness and the edge durability is,

30   however, inadequate.

Upon an examination of other patent specifications within this area, in particular the following four have been noticed. DE-A-39 01 470 discloses a material suited

for, among other things, razor blades and knives. However,
the patent teaches a pressurized metallurgy in order to
achieve contents of nitrogen above 0,20 % by weight, and
thereby maximally twice as high content of carbon as of

5   nitrogen. Furthermore, two experimental alloys are men-
tioned, both with hardness below 600 HV. The patent also
teaches additions of vanadium in low contents. Therefore,
the material will not meet the above-mentioned demand on
hardness and avoidance of the alloy element vanadium, and

10 furthermore, the production cost will become very high.
According to EP-A-638 658, vanadium is used in order to
achieve a strong secondary hardening upon tempering to high
temperatures, which may be an advantage, for instance if
the material is to be coated or used at high temperatures.

15 However, this is objectionable if the material is to be
etched into final form or be used to produce very sharp
edges, according to the above. The patent states 40 μm as
the largest allowable size of carbonitrides unlike the 5 μm
stated as the maximum limit according to the present inven-

20 tion. EP-A-750 687 states the maximum content (carbon +
nitrogen) to 0,55 % by weight, which according to the pres-
ent invention is judged to be a minimal content in order to
achieve sufficient hardness. This is confirmed by the fact
that the aim what relates to hardness in the EP publication

25 is HRC > 50, and that the experimental alloy that achieves
the highest hardness reaches 56,3 HRC (this is after
tempering for 1 h at only 180 °C). This limited hardness in
combination with a small share of remaining carbonitrides
will cause inadequate edge durability for edge applications

30 with high demands. Foremost, the patent specification also
focuses articles with extremely high demands on corrosion
resistance, why also copper has been added, and therefore
the hardness and the hot workability has been neglected. As

regards the patent specification US-A-6 235 237, which
above all relates to steel edges for skis with demands on
damping, the combination of high content of chromium, low
content of molybdenum and low content of nitrogen gives a

5   hardness below 50 HRC according to the examples in the
patent specification, and thereby inadequate edge
durability for edge applications with high demands.

      Thus, a first object of the present invention is to
provide a new steel alloy, which overcomes all the above-

10 mentioned drawbacks of prior art.

      In particular, the object of the present invention is
to provide a steel alloy that has a hardness of at least 56
HRC, has excellent corrosion resistance and can be machined
by means of photoetching.

15   In a surprising way for a person skilled in the art,
these and additional objects have succeeded to be attained
by providing a steel alloy according to the following com-
position (in % by weight):

C	0,40-0,60
Si	0,1-1,0
Mn	0,3-1,0
Cr	12-15
Mo	2,5-4,0
Ni	0-1,0
Co	0-4,0
N	0,15-0,20,

the hardness > 56 HRC being attained without deep freezing,
as well as PRE > 25, defined as

PRE = % Cr + 3,3 · % Mo + 16 · % N. The balance to achieve

30 100 % consists of iron and normally occurring impurities
due to the raw material and/or the manufacturing process.
Preferably, it is considered that the maximum size of
carbides, nitrides and carbonitrides is Ø < 5 µm, in order

to reduce the risk of edge related problems and to be able to dissolve the carbides, nitrides and carbonitrides during austenitisation.

Preferably, the steel alloy according to the present invention has the following composition (in % by weight):

C   0,42-0,60
Si   0,15-0,80
Mn   0,4-0,8
Cr   13-15
Mo   2,6-4,0
Ni   0-0,7
Co   0-0,5
N   0,15-0,20,

as well as the balance Fe and normally occurring impurities.

Even more preferred, the steel alloy according to the present invention has the following composition (in % by weight):

C   0,42-0,50
Si   0,15-0,55
Mn   0,4-0,7
Cr   14-15
Mo   2,6-3,0
Ni   0-0,7
Co   0-0,5
N   0,15-0,20,

as well as the balance Fe and normally occurring impurities.

Materials manufactured according to the present disclosure are especially suitable for the use in applications such as, for instance, knives in the food industry having high demands on hardness and edge durability in combination with corrosion resistance due to

chloride ion-containing environment as well as corrosive
dishwashing detergents. Other areas are cutting edges for
dry and wet shaving, surgical edge applications as well as
diving knives. Additional fields of application for the new
5   material are, for instance, doctor blades in the printing
industry as well as doctor blades (also known as coater
blades) and creping blades in the pulp industry.

Choice of way of manufacture of the material depends,
among other things, on desired material volume, maximum
10   allowed production cost and demands on slag purity. Cus-
tomer requirements such as hardened and tempered, and cold-
rolled, respectively, finish, naturally has also an effect.
However, the manufacture will always comprise a metallurgi-
cal process at normal atmospheric pressure (1 atm = 1 bar).
15   The metallurgical process comprises melting in an electric
arc furnace or a high frequency furnace. The content of
carbon is adjusted either by the choice of alloying materi-
als or by carbon elimination in AOD or CLU or another
refining process. The content of nitrogen is adjusted
20   either by the supply in the form of gas or by the use of
nitrogenous alloying materials. Alternatively, the material
may be remelted in a secondary metallurgical process such
as VIM, VAR, ESR or the like. Casting may be effected into
ingot or via continuous casting, and then hot working fol-
25   lows down to strip form. After the hot working, the mate-
rial is spheroidized and then cold-rolled in a plurality of
steps into desired thickness including intermediate recrys-
tallization annealing operations. Upon customer want of a
hardened and tempered delivery finish, this hardening takes
30   place in a continuous strip process in the form of an
austenitizing in protective atmosphere, a quenching (for
the phase transformation into martensite), and finally a
tempering to desired hardness. The material is then cut

into desired widths or is cut into planar lengths depending
on the customer want. The final product may be produced by
any conventional process; for example, from hardened strip
material by photoetching and forming, or from cold-rolled

5   strip material by punching/cutting, forming, hardening,
tempering and finally grinding. It is also conceivable to
sell the material in the wire, tube or ingot form.

Brief description of the figures

10   Figure 1 illustrates a general outline between three
comparative examples with regard to hardness/edge
durability and corrosion resistance.
         Figure 2 illustrates the result of a CPP test of Alloy
1 and two comparative examples.

15   Figure 3 illustrates the hardness as a function of the
tempering temperature for Alloy 1 and three comparative
examples.
         Figure 4 illustrates the hardness and CPP corrosion
resistance for Alloy 1 and two comparative examples.

20   Figure 5 shows a microphotograph of Alloy 1 according
to the present disclosure illustrating the microstructure
of the composition.
         Figure 6 shows a microphotograph of a comparative
example illustrating the microstructure of the composition.

25   Figure 7 illustrates a comparison between Alloy 1 and
two comparative examples with regard to the hardness levels
and structures.

Example 1

30   One melt of material of the present disclosure, Alloy
1, has been produced in ten ton scale with CLU-metallurgy.
The material has been ingot casted, hot rolled and
thereafter cold rolled with intermediate annealings down to

suitable thickness for evaluation. The melt of the present
invention has the composition as indicated in Table 1,
Alloy 1. The material according to the present disclosure
is compared with three grades: Comparative examples 1-3.
5   The nominal composition of the comparative examples 1-3 is
also given in Table 1.

Table 1. Chemical composition in percent by weight of the
test melt and nominal composition in percent by weight of
10   comparative examples 1-3.

Alloy	C	Si	Mn	Cr	Ni	Mo	Further elements
Alloy 1	0,42	0,33	0,55	14,55	0,15	2,69	Co 0,02 V 0,05 (imp.) Cu 0,03(imp.) N 0,18
Comp. ex. 1	0,60	0,4	0,4	13,5	0,5	0,15	N 0,02
Comp. ex. 2	0,38	0,4	0,55	13,5	0,3	1,0	N 0,072
Comp. ex. 3	0,95	0,4	0,65	13,5	0,5	0,2	N 0,02

A general outline between the comparative examples is
illustrated in Figure 1, showing the hardness versus
corrosion resistance as well as the influence of the
15   alloying elements C, N, Cr and Mo.

Table 2. Result from testing according to ISO 8442.1 and
ISO 8442.5.

Blade description	Hardness		Ret-ained Aust-enite	ISO 8442.5		ISO 8442.1
				ICP, Catra resha-rpening	TCC, Catra resha-rpening	Corro-sion
	(HV 1 kg)	(HRC, Calcul-ated)	(%)	(mm)	(mm)	
Alloy 1, A	666	58,6	7,7	104,5	503,7	P1
Alloy 1, B	665	58,5	8,7	102,8	402,4	P2
Alloy 1, C	673	58,9	8,2	104,8	485,9	P1
Comp. Ex.1, D	653	57,9	8,2	100,4	605,1	F3
Comp. Ex.1, E	655	58,0	8,4	106,5	399,7	P2
Comp. Ex.1, F	653	57,9	8,1	103,7	396,2	P2
Alloy 1, average	668	58,7	8,2	104,0	464,0	Pass
Comp. Ex.1, average	654	57,9	8,2	103,5	467,0	Fail
Total average	661	58,3	8,2	103,8	465,5	

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For evaluation of corrosion resistance and cutting
ability for the material according to the present
disclosure six knife blades were produced and evaluated
according to ISO 8442.1 and ISO 8442.5. Three blades (A-C)
5   were produced in material from Alloy 1, hardened at 1055°C,
deep frozen, and tempered at 275°C to reach hardness
between 58 - 58,5 HRC. Three blades (D-F) were also
produced in the composition according to Comparative
example 1 hardened at 1080°C, deep frozen, and tempered at
10   230°C to reach hardness between 58 - 58,5 HRC. All the
blades were ground and finished in the same equipment to
produce comparable edges and finishes. The result from the
test is shown in the Table 2.

The corrosion test according to ISO 8442.1 shows that
15   the material according to the present disclosure passes the
test whereas the Comparative example 1 fails in the test.
The results from the edge testing according to ISO 8442.5
are on the very same level for the new grade and for
Comparative example 1.

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Example 2

The corrosion properties of the material of the
present disclosure were also measured by anodic
polarization/critical pitting potential (CPP) and compared
25   with Comparative example 1 and Comparative example 2.
Samples were taken from Alloy 1 and from Comparative
example 1 and Comparative example 2 respectively, all
compositions given in Table 1. The sample of Alloy 1 was
hardened at 1035°C, the samples of Comparative example 1
30   were hardened at 1080°C, and the samples of Comparative
example 2 were hardened at 1030°C, according to

recommendation for each alloy. The tempering for all grades
was performed at 225°C. All surfaces of the samples were
finished with 600 grit wet grinding. The test solution was
0,1% NaCl, the test was performed at 20°C, and the
5   potential over the sample was increased with 75 mV/minute
with a start at -600 mV. Nitrogen gas was bubbled through
the solution to reduce the oxygen level. The criteria used
for start of pitting was set to $I > 10$ $\mu A/cm^2$. The result
from the test is shown in Figure 2.

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Example 3

     Hardening tests were performed on material of Alloy 1
and compared with typical data for Comparative example 1,
Comparative example 2 and Comparative example 3. The
15   hardening of Alloy 1 was done at 1035°C and quenching to
20°C, but also at 1055°C in combination with deep freezing
at -70°C. The hardness is shown in Figure 3 as a function
of tempering temperature after tempering for 30 minutes.

     It can be seen that for all normal tempering
20   temperatures in the range 175-450°C Alloy 1 has a higher
hardness than Comparative example 1 and Comparative example
2. For tempering temperatures above 225°C the hardness for
Alloy 1 is also higher than for Comparative example 3
because of an improved tempering resistance of Alloy 1
25   caused by the high alloy contents of molybdenum and
nitrogen, which makes it less sensitive to high
temperatures. This bonus of an improved tempering
resistance of Alloy 1 can be highly beneficial for example
in products where surface coating by PVD or with PTFE is
30   involved.

Example 4

In Figure 4, Alloy 1 is compared with Comparative
example 1 and Comparative example 2 with regard of
corrosion resistance and hardness. All samples were
5   tempered at 225°C and heat treated as described above. It
is desired that the composition possesses a high corrosion
resistance as well as a high hardness. This is illustrated
by an arrow in Figure 4 showing the desired direction of
the properties. It is easily seen that Alloy 1 of the
10   present invention combines an improved hardness as compared
with Comparative example 1 with an improved corrosion
resistance as compared with Comparative example 2.

The typical microstructure for material of Alloy 1 in
the annealed condition is a ferritic matrix with uniformly
15   distributed secondary carbides, nitrides and carbonitrides.
Furthermore, the microstructure of Alloy 1 is free from
primary carbides, nitrides or carbonitrides with a diameter
bigger than 5 μm. A typical structure of Alloy 1 is shown
in Figure 5, wherein the microphotograph is taken in light
20   optical microscope at 1000 x magnification after polishing
and etching of a transverse cross section. Etching was done
in 4% Picric acid with a minor addition of hydrochloric
acid. The average diameter of the carbides, nitrides and/or
carbonitrides was estimated to approximately 0,4 μm.

25   For edge applications where very keen edges are to be
produced either by mechanical methods or by etching the
above structure free from primary carbides with a diameter
larger than 5 μm is necessary to avoid tear outs or etching
defects on the edge. As a comparison a microphotograph,
30   taken under the same conditions, showing the typical
structure for Comparative example 3 is shown in Figure 6.

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In Figure 7 the hardness levels and structures are compared for Alloy 1 of the invention, Comparative example 1 and Comparative example 3.

5   **Example 5**

Since the properties of the steel are highly dependent on the hardening conditions, estimations outgoing from the basic chemical composition may be misleading. Equilibrium calculations at a predetermined suitable hardening
10   temperature using the software ThermoCalc is one way to more accurately calculate the final properties and have been performed for Alloys 2-6, Alloy 1, as well as Comparative examples 1-3. The compositions of Alloys 2-6 are given in Table 3 and the results of the calculations
15   are shown in Table 4.

The database used has been TCFE3. Optimal hardening temperatures have been selected and used in the modelling for the different grades. Outgoing from the austenite phase composition at hardening temperature, values for PRE, M_s
20   and weight percent of the interstitials nitrogen and carbon have been calculated. Also the phase percentage of $M_{23}C_6$ carbide in equilibrium with the austenitic phase, which is an important factor for wear and edge durability, has been calculated. For PRE, the previously discussed equation has
25   been used. M_s was calculated using Andrew's formula, as shown below:

$$M_s = 539 - 423*C - 30,4*Mn - 12,1*Cr - 17,7*Ni - 7,5*Mo + (-423*N - 7,5*Si + 10*Co)$$

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Table 3. Compositions of Alloys 2-6 in percent by weight.

Alloy	C	Si	Mn	Cr	Ni	Mo	Further elements
Alloy 2	0,45	0,2	0,5	12,5	0,7	3,8	N 0,18
Alloy 3	0,55	0,3	0,5	12,5	0,6	2,9	Co 1,0 N 0,18
Alloy 4	0,55	0,2	0,5	13,5	0,5	3,5	N 0,18
Alloy 5	0,45	0,4	0,5	13,5	0,4	3	Co 2,0 N 0,18
Alloy 6	0,45	0,4	0,5	14,5	0,3	2,5	N 0,18

Comparison between Alloy 1 and Comparative example 1
shows that the steel according to the invention has
significantly higher PRE-values but at the same time
comparable interstitial content and amount of carbide
phase, which should result in a steel with similar hardness
and edge performance but significantly increased corrosion
resistance. Comparative example 2 is closer to Alloy 1 in
PRE but the lower amount of interstitials in the matrix
together with a lower amount of carbide phase predicts a
lower hardness and inferior edge properties. These data
correspond to the actual measurements in the previous
example. The M_s-temperature for Alloy 1 is lower than both
Comparative example 2 and Comparative example 1 but in the
same range as Comparative example 3, which has a known good
hardenability, but where the carbide content significantly

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higher resulting in a coarser microstructure as shown
before in Figure 6.

Table 4. Results of Thermo-Calc calculations.

Alloy	Hard-ening Temp. ($^{\circ}$C)	PRE Alloy	PRE Aust-enite	C+N (wt-%) Aust-enite	$M_{23}C_6$ (mole-%)	M_s-Temp. ($^{\circ}$C)
Alloy 1	1035	26,3	24,7	0,48	3,0	132
Alloy 2	1035	27,9	25,8	0,52	2,4	121
Alloy 3 .	1035	25,0	22,9	0,57	4,0	124
Alloy 4	1035	27,9	25,2	0,53	4,9	121
Alloy 5	1035	26,3	24,5	0,50	3,2	151
Alloy 6	1035	25,6	23,8	0,49	3,4	129
Comp. Ex. 1	1080	14,3	13,4	0,51	2,7	147
Comp. Ex. 2	1030	18,0	17,2	0,39	1,4	184
Comp. Ex. 3	1060	14,5	11,4	0,57	9,6	137

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Alloys 2-6 are other possible embodiments of the
composition according to the present disclosure, that
result in different properties even though the difference

in chemical composition is small. Alloys 2 and 4 have comparable values for PRE, interstitial content and M_s, which results in similar corrosion resistance, hardness and hardenability but with about twice the amount of $M_{23}C_6$ carbides in Alloy 4, the edge durability will be higher in this grade. Highest amount of interstitials in the matrix and thus the highest expected hardness is achieved in Alloy 3, which still has a sufficient hardenability due to the addition of Cobalt. Alloy 5 has even higher amount of cobalt compared to Alloy 6, which improves the hardenability even further without drastically changing the other properties.